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Postharvest Wax-Fungicide Treatments of Nectarines, Peaches, and Plums for:

- Reducing Decay
- Reducing Moisture Loss
- Enhancing External Appearance

Marketing Research Report No. 981

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PREFACE

This research was supported in part by the California Tree Fruit Agreement, Sacramento, Calif., and the Fresh Peach Advisory Board, Fresno, Calif. In addition, the author acknowledges the cooperation and assistance of the following growers and packers:

Leroy Giannini, Giannini Packing Corp., Dinuba, Calif.
Frank and John Sleeter, Hill High Orchards, Round Hill, Va.
Jack Steigmeyer, Steigmeyer Orchards, Cumberland, Md.

Acknowledgement is also extended to A. J. Kraght and Gary Cable, Decco Division, Pennwalt Corp., Monrovia, Calif., and Charlestown, W. Va., respectively, for their help in providing the necessary equipment for this project.

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Washington, D.C. Issued May 1973

For sale by the Superintendent of Documents,
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Price: 20 cents, domestic postpaid; 10 cents, GPO Bookstore
Stock No. 0100-027

981, 6 p.

2001

Postharvest Wax-Fungicide Treatments of Nectarines, Peaches, and Plums for:

• Reducing Decay
• Reducing Moisture Loss
• Enhancing External Appearance

By John M. Wells, *plant pathologist, Southeastern Fruit and Tree Nut Research Station, Southern Region, Byron, Ga., Agricultural Research Service, United States Department of Agriculture*

SUMMARY

Experimental postharvest treatments of peaches and nectarines with wax sprays containing 450 p.p.m. Botran plus 33 to 333 p.p.m. benomyl were as effective in reducing decay as commercially used wax treatments with 1,800 p.p.m. Botran. Supplements of 100 or 333 p.p.m. EL–273 or Mertect to 450 p.p.m. Botran were also effective. Moisture loss in peaches, plums, and nectarines during a simulated retail store holding period was reduced by at least 33 percent with dilutions of four waxes tested. Oil and shellac-based waxes imparted a high gloss to treated nectarines.

In commercial tests, treatments of peaches and nectarines with a paraffin-base wax containing 450 p.p.m. Botran plus 333 p.p.m. benomyl resulted in a 95-percent reduction of decay and a 70-percent reduction in weight loss when the fruit was stored for 3 days at 37° F. and then held for 3 to 5 days at 70°.

BACKGROUND

The most important postharvest diseases of peaches (*Prunus persica* [L.] Batsch) and nectarines (*P. persica* [L.] Batsch var. *nectarina* [Ait.] Maxim.) are brown rot caused by *Monilinia fructicola* (Wint.) Honey and rhizopus rot caused by *Rhizopus stolonifer* (Ehr. ex Fr.) Lind. Black-mold rot (*Aspergillus niger* v. *Teigh*) and blue mold rot (*Penicillium* sp.) occur occasionally (*2*).[1] These diseases are limiting factors in the storage and marketing life of the fruit. In 1968, postharvest rots of peaches caused 15– and 25–percent losses in the New York and Chicago markets, respectively (unpublished data, Agricultural Research Service, U.S. Department of Agriculture) and comparable losses to nectarine growers and shippers in California (personal communications).

Research on postharvest decay of peaches and nectarines has emphasized new methods of control, such as hot water dips (*8*), combination hot water-fungicide dips (*7*, *11*), and heated wax-fungicide sprays (*10*). Many packing sheds, however, still use a commercial waxing process that applies a wax-fungicide spray on the fruit moving across rotating brushes. The effectiveness of wax-fungicide treatments can be improved by increasing the fungicide residues on treated fruit (*6*, *12*). Another improvement—the subject of this report—is the selection of more effective fungicides or combinations of fungicides to control decay. The following list contains the common, trade, or chemical names of the fungicides included in the experiments described here.

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[1] Italic numbers in parentheses refer to Literature Cited, p. 6.

Common or trade name	*Chemical name*
Benomyl	Methyl-1- butyl - carbamoyl-2-benzimidazolecarbamate.
Botran	2,6-dichloro-4-nitroaniline.
Dowicide A	Sodium o-phenylphenate tetrahydrate.
EL–273	a-2,4-dichloro-phenyl-a-phenyl-5-pyrimidine methanol.
Metect	2-(4-thiazolyl) benzimidazole.

The fungicide Botran is most commonly used in combination with waxes to reduce postharvest decay. Supplementing Botran with the "systemic" fungicide benomyl results in a significant improvement in the effectiveness of the treatment (*12*). Other recently developed systemic fungicides are as yet untested in combination with wax treatments. In this report, benomyl and two recent systemic fungicides, EL–273 and Mertect, are evaluated for their effectiveness as supplements in Botran-wax combinations.

Although the systemic fungicides, at concentrations of 100 to 333 parts per million (p.p.m.), are effective against brown rot (Monilinia infections), they are not effective against rhizopus rot (*5*). Thus, their use is limited as supplements to broad-spectrum fungicides, such as Botran, or in combination with heat treatments (*7*). A postharvest wax application containing 450 p.p.m. Botran is considered minimal for control of rhizopus rot, but 1,800 p.p.m. is required for control of brown rot (*10*). Therefore, addition of an effective systemic fungicide to a minimal concentration of Botran would permit an overall reduction in the total amount of fungicides used to control postharvest decay of peaches and nectarines.

MATERIALS AND METHODS

Peaches and nectarines also are waxed to prevent shriveling due to moisture loss (*4*), and to enhance their appearance (*3*). At retail level, fruits may lose 5 to 10 percent of their original fresh weight, and their luster and firmness.

Waxes are generally sprayed on the fruit as diluted emulsions. No reports have been published on the relative effectiveness of different types of wax coating in preventing moisture loss from peaches, plums, and nectarines (*1*). The type of wax used may also affect the gloss and appearance of the fruit in the market.

This report describes the effect of different wax-fungicide combinations on the incidence of postharvest decay of peaches and nectarines and the effects of different types of waxes on the preventing moisture loss and enhancing the external appearance of treated fruit.

Freshly harvested fruit were obtained either from orchards or packing sheds. The fruits were selected for uniform maturity and for absence of injury or decay. Samples of 60 to 120 fruits per treatment were used to evaluate decay control and 9 to 20 fruits per treatment to determine the effect of waxes on weight loss. Experiments were replicated at least four times, each time with a different variety of fruit.

Experimental treatments were conducted with western-grown fruit in Fresno, Calif., in 1970, and selected treatments were tested with eastern-grown fruit in commercial packing sheds in Cumberland, Md., and Round Hill, Va., in 1971.

Laboratory treatments of the western-grown fruit were conducted in a small commercial waxer in which the fruit was washed against rotating brushes in a spray containing a 0.03 percent solution of a detergent sodium dodecylbenzenesulfonate. The fruit then was rinsed in fresh water and sprayed with a wax or wax-fungicide emulsion for approximately 3 seconds. Fungicides were suspended in a 15-fold dilution of a concentrated paraffin-base wax (Decco Peach Wax WT–52) containing 0.2 to 2.5 percent Dowicide A as a wax preservative.

Fungicides and combinations tested were (1) Botran at 450, 900, and 1,800 p.p.m. active ingredients (½, 1, and 2 pounds of Botran 75 W per 100 gallons of wax emulsion, respectively) and (2) benomyl, EL–273, and Mertect at 33, 100, and 333 p.p.m. (active ingredients), all in combination with 450 p.p.m. Botran.

In the laboratory experiments with western-grown fruit, treated fruits were packed in commercial lugs with plastic trays and stored for 3 days at 35° F. The fruits then, were held for 5 to 6 days at 70° to simulate retail store display conditions, after which they were examined for decay or injury. Fruit was considered decayed if monilinia, rhizopus, penicillium, or aspergillus rot were present at any stage of development.

Fruits were dipped for 3 seconds in 6-, 12-, and 25-fold dilutions of four types of waxes to determine the relationship between wax dilutions and weight loss. Two varieties each of peaches (Dixie Red and Red Haven), nectarines (Red June and Early Sungrand), and plums (Rosa Grande and Nubiana) were included in the tests. Waxes tested were (1) a paraffin-base emulsion in water consisting of 28-percent solids, (2) an emulsion in water of an oxidized low-molecular-weight polyethylene consisting of 25-percent solids and 1-percent oil, (3) a shellac-base emulsion with a wetting agent consisting of 15-percent solids, and (4) an emulsion of cottonseed oil in water composed of 28-percent oil.

Waxed and nonwaxed fruits were weighed within 2 hours after treatment, stored for 3 days at 35° F. and held for 4 days at 70°, and then weighed again. Relative humidity in the storage rooms ranged from 75 to 90 percent. Weight losses were calculated for each fruit and expressed as average percentages of the initial weights. Groups of six nectarines and peaches were rated for surface gloss within 2 hours after waxing. A rating scale was used in which 1=no different than the unwaxed checks, 2=slight gloss, 3=moderate gloss, and 4=high gloss. Plums were not rated for surface luster.

The eastern-grown fruit was given selected treatments in commercial packing sheds equipped with waxing units. Fruits were treated, packed in loose bulk, stored for 3 days at 37° F., held for 4 to 6 days at 70° F., and then examined for decay or injury. Storage conditions for moisture lots determinations were 9 days at 37° plus 1 day of holding at 70°.

Data were evaluated by analysis of variance and by Duncan's Multiple Range Test. Decay percentages were transformed to arc sines before analysis (*9*). Differences were considered significant at the 5-percent level.

RESULTS

Botran Treatments Supplemented With Benomyl, Mertect, or EL–273—Laboratory Tests

The natural level of decay in untreated lots of two varieties of peaches and six varieties of nectarines (dry checks) averaged 21.45 percent after a simulated storage and marketing period (table 1). Fruits that were washed and sprayed with a wax-emulsion containing no fungicides other than a preservative (Dowicide A) averaged 11.25-percent decay. Fruits treated with wax containing a minimum level of Botran (450 p.p.m.) developed 7.94-percent decay—a value not statistically different from that of the wax checks. However, Botran levels of 900 and 1,800 p.p.m. (a range in commercial use) significantly reduced decay to 4.88 and 2.80 percent, respectively.

In general, treating fruit with wax plus 450 p.p.m. Botran supplemented with 33 p.p.m. benomyl or with 100 or 333 p.p.m. of any other fungicide was as effective as treating the fruit with 1,800 p.p.m. Botran in wax only. The 1,800 p.p.m. Botran treatment, however, was significantly more effective than treatments with 450 p.p.m. Botran plus 33 p.p.m. Mertect or EL–273. Botran with Mertect supplements, within the concentrations tested, were no more effective than 450 p.p.m. Botran alone. However, Botran supplemented with benomyl or EL–273 at 100 or 333 p.p.m. was significantly more effective in reducing decay development than Botran alone at 450 p.p.m.

Fruits treated with 450 p.p.m. Botran and 333 p.p.m. benomyl developed an average of 1.66-percent decay—significantly less than that in lots treated with 900 p.p.m. Botran. The corresponding Botran and EL–273 treatments resulted in about equal control (1.67-percent decay).

Moisture Loss and Appearance of Wax-Dipped Fruit—Laboratory Tests

Unwaxed peaches, plums, and nectarines stored for 3 days at 35° F. and then held for 4 days at 70° lost an average of 11.7 percent of their original fresh weight (fig. 1) and appeared dull and shriveled. Fruit dipped in 6-, 12-, or 25-fold dilutions of four waxes averaged losses between 6.3 and 9.6 percent of their original fresh weights. Moisture loss increased linearly as the wax was diluted with water. A 33-percent reduction of average weight loss was achieved with the following dilutions of each wax tested: 7-fold dilution of the shellac-base wax; 11-fold dilution of the oil-base wax, 17-fold dilution of the polyethylene-base wax; and a 25-fold dilution of the paraffin-base wax. Fruit treated with these dilutions did not shrivel

Table 1.—*Decay in peaches and nectarines treated for 3 seconds with wax and wax-fungicide emulsions,*[1] *then stored for 3 days at 35° F., and held 5 to 6 days at 70°*

Type of treatment and concentration of fungicide (p.p.m.)	Decay in peach varieties [2]		Decay in nectarine varieties [2]						Means for decay [3]
	Red Top	Late Suncrest	Regular Sungrand	Late Le Grand	Late Le Grand	Regular Le Grand	Flame Kist	Gold King	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
No treatment (dry check)	1. 7	27. 5	5. 8	16. 7	48. 3	25. 0	33. 3	13. 3	21. 45 f
Wax only	5. 8	11. 7	6. 7	13. 3	21. 7	10. 0	10. 0	10. 8	11. 25 e
Wax+Botran at 450:									
Only	2. 5	15. 0	6. 7	4. 2	14. 2	6. 7	5. 0	9. 2	7. 94 de
Plus benomyl at—									
33	0	. 8	. 8	1. 7	16. 7	10. 0	10. 0	6. 7	5. 84 cd
100	0	2. 5	1. 7	0	14. 2	5. 0	3. 3	4. 2	3. 86 abc
333	0	. 8	. 8	1. 7	2. 5	1. 7	0	5. 8	1. 66 a
Plus Mertect at—									
33	2. 5	7. 5	4. 7	3. 3	9. 2	11. 7	3. 3	16. 7	7. 36 de
100	1. 7	4. 2	2. 5	3. 3	9. 2	1. 7	3. 3	15. 0	5. 11 bcd
333	1. 7	5. 8	2. 5	1. 7	. 8	5. 0	11. 7	6. 7	4. 47 bcd
Plus EL–273 at—									
33	1. 7	6. 7	5. 0	4. 2	10. 0	10. 0	11. 7	11. 7	7. 62 de
100	1. 7	4. 2	. 8	2. 5	5. 0	0	10. 0	10. 8	4. 37 abc
333	1. 7	2. 5	. 8	2. 5	0	1. 7	1. 7	2. 5	1. 67 ab
Wax+Botran at 900	1. 7	5. 8	5. 0	3. 3	7. 5	5. 0	3. 3	7. 5	4. 88 bcd
Wax+Botran at 1,800	. 8	. 8	0	3. 3	5. 0	8. 3	1. 7	2. 5	2. 80 abc

[1] Percentages are based on number of fruits with decay and number of fruits (60 to 120) in each treatment.

[2] 15-fold dilution of paraffin-base wax emulsion containing 133 to 300 p.p.m. Dowicide A.

[3] Averages not followed by the same letter are significantly different at the 5-percent level. Tests for significance based on arc sine transformations of data (*9*).

significantly during the experimental holding period.

Shellac- and oil-base waxes used as a dip treatment imparted a high luster to nectarines but did not significantly affect the surface luster of peaches. Average ratings for surface gloss on nectarines were 1.0 for the unwaxed checks; for the wax-dipped fruit, these ratings were 1.8 for the paraffin-base wax, 2.2 for the polyethylene-base wax, 3.4 for the oil-base wax, and 3.6 for the shellac-base wax.

Commercial Wax-Fungicide Treatments

Samples of eastern-grown peaches and nectarines treated under commercial conditions with wax emulsions containing 1,800 p.p.m. Botran, or 450 p.p.m. Botran plus 333 p.p.m. benomyl, developed an average of 2.2- to 3.5-percent decay compared with 45.5-percent decay in samples processed on the packing line with water spray but no wax-fungicide treatment (wet checks). As in the experimental results on western-grown fruit, no significant differences were found in the effectiveness of the two wax-fungicide treatments in controlling decay (table 2). Treated lots had 95 percent less decay than the wet check, a reduction similar to that observed under laboratory conditions with California fruit.

Moisture weight loss from fruits not processed on the packing line (dry checks) averaged 1.6 percent after 9 days of storage at 37° F., and 1 day of holding at 70°. Fruits that were recovered from the packing line but not sprayed with wax lost 4.1 percent of their original fresh weight. Waxing fruit on the packing line reduced weight loss

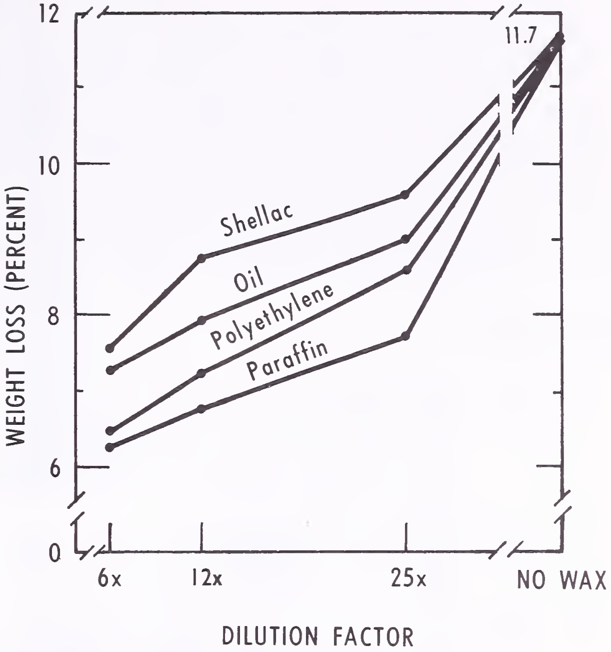

Figure 1.—Weight loss in fruit dipped in three dilutions each of four wax emulsions, during storage for 3 days a 35° F. and holding period of 4 days a 70°. Each point represents an average of 20 samples of two varieties each of peaches, plums, and nectarines.

from 1.1 to 1.4 percent—values similar to that of the unprocessed dry checks.

No injury or undesirable effects were observed on the skin or flesh of fruit treated with wax-fungicide emulsions under the conditions tested.

DISCUSSION

The new systemic fungicides, such as benomyl, can be effectively incorporated into postharvest wax-fungicide treatments for peaches and nectarines. A combination of 450 p.p.m. Botran and 333 p.p.m. benomyl was as effective as 1,800 p.p.m. Botran alone. By combining different fungicides at minimal concentrations with each fungicide selected for its action against a specific type of fruit decay, the use of chemicals can be reduced overall. The Environmental Protection Agency (EPA) permits the postharvest use of both Botran and benomyl, but not Mertect or EL–273, on peaches and nectarines. EPA has not approved the use of any of these materials on plums.

Among the advantages of using waxes on peaches and nectarines are the reduction of moisture loss, the improvement of surface luster on nectarines, and the use of wax as a carrier for post-

Table 2.—*Decay and moisture loss in eastern-grown peaches and nectarines commercially processed with and without wax-fungicide treatments* [1]

Type of treatment and concentration of fungicide (p.p.m.)	Decay and average weight loss [2]									
	Peach varieties						Nectarine variety, Red Grand		Mean for all varieties [3]	
	Saunders		Early Red		Sun High					
	Decay	Weight loss	Decay	Weight loss	Decay	Weight loss	Decay	Weight loss	Decay	Weight loss
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
No treatment (dry check)	0	1. 8	6	1. 7	0	1. 3	6	1. 4	3. 0a	1. 6a
Water spray only (wet check)	25	4. 5	66	5. 1	58	4. 5	33	2. 2	45. 5b	4. 1b
Wax + Botran at 1,800	0	2. 5	2	1. 1	0	2. 0	12	. 8	3. 5a	1. 1a
Wax + Botran at 450 p.p.m. + benomyl at 33 p.p.m.	2	2. 2	0	1. 2	5	1. 8	2	. 6	2. 2a	1. 4a

[1] 3-second spray of 12-fold dilution of paraffin-base wax emulsion containing 133 to 300 p.p.m. Dowicide A and indicated fungicide.

[2] Decay percentages are based on number of fruits showing decay and number of fruits (50 to 60) in each treatment, after storage for 3 days at 37° F. and 1 day of holding at 70°. Average weight loss percentages are based on moisture loss in lots of 9 fruits each, after storage for 9 days at 37° F. and 1 day of holding at 70°.

[3] Averages not followed by the same letter are significantly different at the 5-percent level.

harvest fungicides. The degree of moisture loss reduction is related to the amount of wax applied to the fruit. Therefore, enough wax should be applied to significantly reduce weight loss and shrivel. Too much wax may interfere with a normal exchange of gases between the fruit and its environment and cause internal browning (*2*). The amount of wax used in these studies caused no internal injury to the fruit.

Surface gloss was high on nectarines treated with oil- or shellac-base waxes. These waxes, however, had to be applied in relatively concentrated form to significantly reduce weight loss. Paraffin and polyethylene-wax treatments resulted in the lowest surface gloss ratings, but they were most effective in reducing moisture loss. In selecting waxes, the individual shipper must decide which factor, gloss or moisture loss, is of most concern.

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